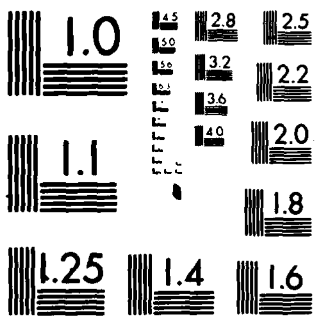
AD-A112 482 CENTER FOR NAVAL ANALYSES ALEXANDRIA VA NAVAL STUDIE--ETC F/G 12/1
TESTING FOR STRUCTURAL CHANGE BY D-METHODS IN SWITCHING SIMULTA--ETC(U)
FEB 82 L LEE, G S MADDALA, R P TROST N00014-76-C-0001
UNCLASSIFIED CNA-PP-342 NL

END
DATE FILMED
4-82
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(2)

PROFESSIONAL PAPER 342 / February 1982

AD A112482

TESTING FOR STRUCTURAL CHANGE BY D-METHODS IN SWITCHING SIMULTANEOUS EQUATIONS MODELS

Lung-Fei Lee
G. S. Maddala
R. P. Trost

DTIC
ELECTE
MAR 26 1982
A

This document has been approved for public release and sale; its distribution is unlimited.

CNA

CENTER FOR NAVAL ANALYSES

82

The ideas expressed in this paper are those of the author.
The paper does not necessarily represent the views of either
the Center for Naval Analyses or the Department of Defense.

PROFESSIONAL PAPER 342 / February 1982

TESTING FOR STRUCTURAL CHANGE BY D-METHODS IN SWITCHING SIMULTANEOUS EQUATIONS MODELS

Lung-Fei Lee
G. S. Maddala

AD NUMBER	DATE	DTIC ACCESSION NOTICE
	Feb 82	

1. REPORT IDENTIFYING INFORMATION

A. ORIGINATING AGENCY
Center for Naval Analyses

B. REPORT TITLE AND/OR NUMBER
PP 342, Testing for Structural Chage by D-Methods

C. MONITOR REPORT NUMBER

D. PREPARED UNDER CONTRACT NUMBER
N00014-76-C-0001

2. DISTRIBUTION STATEMENT
Cleared for Public Release

REQUESTER:

1. *Put your mailing address on reverse of form.*
2. *Complete items 1 and 2.*
3. *Attach form to reports mailed to DTIC.*
4. *Use unclassified information only.*

DTIC:

1. *Assign AD Number.*
2. *Return to requester.*

DTIC FORM 50 DEC 80 PREVIOUS EDITIONS ARE OBSOLETE

CENTER FOR NAVAL ANALYSES

PROFESSIONAL PAPER 342 / February 1982

TESTING FOR STRUCTURAL CHANGE BY D-METHODS IN SWITCHING SIMULTANEOUS EQUATIONS MODELS

Lung-Fei Lee
G. S. Maddala
R. P. Trost

N00014-76-C-0001

Accession For
letter on file
A

DTIC
COPY
INSPECTED
2

Naval Studies Group

CENTER FOR NAVAL ANALYSES

2000 North Beauregard Street, Alexandria, Virginia 22311

TESTING FOR STRUCTURAL CHANGE BY D-METHODS IN SWITCHING SIMULTANEOUS EQUATIONS MODELS*

Lung-fei Lee, University of Minnesota
G. S. Maddala, University of Florida
and R. P. Trost, Center for Naval Analyses

1. Introduction

Goldfeld and Quandt (1972) considered a switching regression model with two regimes:

$$y_i = a_1 + b_1x_i + u_{1i} \quad (1)$$

$$y_i = a_2 + b_2x_i + u_{2i} \quad (2)$$

$u_{1i} \sim IN(o, \sigma_1^2)$ and $u_{2i} \sim IN(o, \sigma_2^2)$

They assume that there is an identifiable variable Z_i such that if $Z_i < Z_0$ then the observations are generated by (1) and if $Z_i \geq Z_0$ then the observations are generated by (2). They then define the step function

$$\begin{aligned} D(Z_i) &= 1 \text{ if } Z_i < Z_0 \\ &= 0 \text{ if } Z_i \geq Z_0 \end{aligned} \quad (3)$$

Later, instead of considering the step function, they consider $D(Z_i)$ to be a cumulative normal given by

$$\begin{aligned} D(Z_i) &= 1 \text{ if } Z_i < Z_0 + \varepsilon_i \\ &= 0 \text{ if } Z_i \geq Z_0 + \varepsilon_i \end{aligned}$$

where ε_i IN (0,1).

The model considered by Goldfeld and Quandt is an exogenous switching model because ε_i is assumed to be independent of u_{1i} and u_{2i}. Goldfeld and Quandt (1973) give an extension of the switching regression model to simultaneous equations systems but the extension is still in the framework of exogenous switching.

Maddala and Nelson (1975) discuss extensions of the Goldfeld-Quandt switch-regression model to the case of endogenous switching.[1] Many of the practical problems one encounters - disequilibrium models, selectivity models etc., are all switching regression models with endogenous switching. The present paper extends the D-method suggested by Goldfeld and Quandt to switching simultaneous equations systems with endogenous switching.

There have been previous discussions of structural change by Heckman (1976b) in models with endogenous switching. However, the type of model we discuss has not been considered by him. What he considers is a shift in the constant term (a structural shift) and not shifts in all the coefficients as we do.

What the D-method does is to combine the equations in the two regimes into a single equation. This will enable us to apply tests for equality of specific coefficients in the two regimes. The alternative to this procedure would be to use a likelihood ratio test every time the significance of a particular coefficient needs to be tested. Thus, the D-method has the advantage of computational simplicity. In this paper we suggest instrumental variable methods to estimate the parameters of the combined equation. Following the methods used by Amemiya (1978), we derive the asymptotic covariance matrix (in the appendix) and present an empirical example illustrating the use of the suggested method.

2. The Switching Simultaneous Equation System

The general model we consider in this paper is the following:

$$I_i = x_i'\delta - \varepsilon_i^* \quad (4)$$

$$\text{Regime 1: } B_1Y_{1i} + \Gamma_1Z_{1i} = \varepsilon_{1i} \text{ if } I_i > 0 \quad (5)$$

$$\text{Regime 2: } B_2Y_{2i} + \Gamma_2Z_{2i} = \varepsilon_{2i} \text{ if } I_i \leq 0 \quad (6)$$

The residuals ε_1, ε_2, and ε^* have a multivariate normal distribution with mean vector 0 and covariance matrix

$$\Sigma = \begin{pmatrix} \Sigma_{11} & \Sigma_{12} & \Sigma_{1*} \\ & \Sigma_{22} & \Sigma_{2*} \\ & & 1 \end{pmatrix}$$

Define the dummy variable

$$\begin{aligned} D_i &= 1 \text{ if } I_i > 0 \\ &= 0 \text{ if } I_i \leq 0 \end{aligned}$$

*Financial support from the National Science Foundation under grant Soc. 78-09473 to the University of Florida is gratefully acknowledged.

Without loss of generality, let us consider the first equation in the two regimes and assume that the endogenous variables occurring in both are the same. Let the observed endogenous variables be

$$y^*_{ji} = y_{1ji} \quad \text{if} \quad D_i = 1$$
$$= y_{2ji} \quad \text{if} \quad D_i = 0 \tag{7}$$

Let us write the first equation in the two regimes as

$$y_{11i} = \beta_{112}y_{12i} + \beta_{113}y_{13i} + \cdots$$
$$+ \beta_{11p}y_{1pi} + \gamma_{11}z_i + \varepsilon_{11i} \tag{8}$$

and

$$y_{21i} = \beta_{212}y_{22i} + \beta_{213}y_{23i} + \cdots$$
$$+ \beta_{21p}y_{2pi} + \gamma_{21}z_i + \varepsilon_{21i} \tag{9}$$

These two equations can be combined into a single equation and written as:

$$y^*_{1i} = D_i y^*_{2i}(\beta_{112} - \beta_{212}) + \cdots$$
$$+ D_i y^*_{pi}(\beta_{11p} - \beta_{21p})$$
$$+ y^*_{2i}\beta_{212} + \cdots + y^*_{pi}\beta_{21p}$$
$$+ D_i z_i(\gamma_{11} - \gamma_{21}) + z_i\gamma_{21}$$
$$+ D_i\varepsilon_{11i} + (1-D_i)\ \varepsilon_{21i} \tag{10}$$

Let us define

$$\phi_i = \phi(x_i'\delta)$$

and

$$\Phi_i = \Phi(x_i'\delta) \tag{11}$$

where x_i is the ith observation of x $i=1, 2..N$ ϕ_i the standard normal density evaluated at $x_i'\delta$ and Φ_i is the cumulative normal:

$$\Phi_i = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x_i'\delta} e^{-u^2/2}\, du$$

Note that $E(\varepsilon_{11i} \mid I_i > 0) = -\sigma_{\varepsilon 11*}\dfrac{\phi_i}{\Phi_i}$

where $\sigma_{\varepsilon 11*} = \text{Cov}(\varepsilon_{11}, \varepsilon^*)$

Similarly $E(\varepsilon_{21i} \mid I_i \leq 0) = \sigma_{\varepsilon 21*}\dfrac{\phi_i}{1-\Phi_i}$

where $\sigma_{21*} = \text{Cov}(\varepsilon_{21}, \varepsilon^*)$

Hence, the composite residual in (10) has the expectation

$$E[D_i\varepsilon_{11i} + (1-D_i)\ \varepsilon_{21i}] =$$
$$(\sigma_{\varepsilon 21*} - \sigma_{\varepsilon 11*})\ \phi_i$$

Equation (10) can now be written as

$$y^*_{1i} = D_i y^*_{2i}\ (\beta_{112} - \beta_{212}) + \cdots$$
$$+ D_i y^*_{pi}\ (\beta_{11p} - \beta_{21p}) + y^*_{21}\beta_{212} + \cdots$$
$$+ y^*_{pi}\beta_{21p} + \Phi_o z_i(\gamma_{11}-\gamma_{21}) + z_i\gamma_{21}$$
$$+ \phi_i\ (\sigma_{21*} - \sigma_{11*}) + \xi_{1i} \tag{12}$$

where $E(\xi_{1i}) = 0$.

3. Estimation Under D-Methods

To estimate equation (12) and develop valid statistical tests we will extend the two-stage estimations method that Heckman (1976a) suggested. First, we get an estimate $\hat{\delta}$ of δ by probit maximum likelihood applied to equation (4).

Second, we estimate the reduced form equations for the endogenous variables in (8) and (9) by the following two stage method.

The reduced form equation for y_{1ji} can be written as

$$y_{1ji} = z_i\pi_{1j} + v_{1ji} \tag{13}$$

Since $E(V_{1ji} \mid I_i > 0) + -\sigma_{ij*}\dfrac{\phi_i}{\Phi_i}$

where $\sigma_{ij*} = \text{Cov}(v_{1j}, \varepsilon^*)$

We can write (13) as

$$D_i y_{1ji} = \Phi_i z_i\pi_{1j} - \sigma_{1j*}\ \phi_i + \eta_{1ji} \tag{14}$$

where $E(\eta_{1ji}) = 0$.

We estimate equation (14) by ordinary least squares substituting $\hat{\phi}_i$ and $\hat{\Phi}_i$ for ϕ_i and Φ_i respectively.

Here $\hat{\phi}_i$ and $\hat{\Phi}_i$ are the same as ϕ_i and Φ_i with $\hat{\delta}$ substituted for δ. This two-stage estimation gives us consistent estimates $\hat{\pi}_{ij}$ and $\hat{\sigma}_{1j*}$, and we can construct the instrumental variable

$$D_i y_{1ji} = \hat{\Phi}_i z_i\hat{\pi}_{1j} - \hat{\sigma}_{1j*}\hat{\phi}_i \tag{15}$$

From the reduced form equations for y_{1ji} and y_{2ji}, one has

$$y^*_{ji} = \Phi_i z_i\pi_{1j} + (1-\Phi_i)z_i\pi_{2j} +$$
$$(\sigma_{2j*}-\sigma_{1j*})\phi_i + V_{ji}$$

where $E(V_{ji}) = 0$ (16)

We estimate equation (16) by ordinary least squares substituting $\hat{\phi}_i$ and $\hat{\Phi}_i$ for ϕ_i and Φ_i to get consistent estimates $\hat{\pi}_{1j}$, $\hat{\pi}_{2j}$ and $\sigma_{2j*} - \sigma_{1j*}$.

Now we construct instrumental variables for y^*_{ji} in (12) as follows

$$\hat{y}^*_{ji} = \hat{\phi}_i Z_i \hat{\pi}_{1j} + (1-\hat{\phi}_i) Z_i \hat{\pi}_{2j} + \hat{\phi}_i \widehat{(\sigma_{2j} - \sigma_{1j*})} \tag{17}$$

With these instrumental variables constructed, one can estimate the structural coefficients from the following modified equations:

$$\begin{aligned} y^*_{1i} = {} & D_i y^*_{2i} (\beta_{112} - \beta_{212}) + \cdots \\ & + D_i y^*_{pi} (\beta_{11p} - \beta_{21p}) \\ & + y^*_{2i} \beta_{212} + \cdots + y^*_{pi} \beta_{21p} \\ & + \hat{\phi}_i Z_i (\gamma_{11} - \gamma_{21}) + Z_i \gamma_{21} \\ & + \hat{\phi}_i (\sigma_{\varepsilon 21*} - \sigma_{\varepsilon 11*}) + \eta_{1i} \end{aligned} \tag{18}$$

where
$$\begin{aligned} \eta_{1i} = {} & \xi_{1i} + (D_i - \phi_i)\ Z_i (\gamma_{11} - \gamma_{21}) \\ & + (\phi_i - \hat{\phi}_i)\ Z_i (\gamma_{11} - \gamma_{21}) \\ & + (\phi_i - \hat{\phi}_i)(\sigma_{\varepsilon 21} - \sigma_{\varepsilon 11*}) \end{aligned} \tag{19}$$

and

$$\begin{aligned} \xi_{1i} = {} & D_i \varepsilon_{11i} + (1 - D_i) \varepsilon_{21i} \\ & - (\sigma_{\varepsilon 21*} - \sigma_{\varepsilon 11*}) \phi_i \end{aligned} \tag{20}$$

In matrix notation, let

$$\begin{aligned} W = [& Dy^*_2, Dy^*_3, \ldots, Dy^*_p, \\ & y^*_2, \ldots y^*_p, \hat{\phi} Z,\ Z, \hat{\sigma}] \end{aligned} \tag{21}$$

and
$$\begin{aligned} \theta' = (& \beta_{112} - \beta_{212}, \ldots, \beta_{11p} - \beta_{21p}, \beta_{212}, \\ & \ldots, \beta_{21p}, \gamma_{11} - \gamma_{21}, \\ & \gamma_{21}, \sigma_{\varepsilon 21*} - \sigma_{\varepsilon 11*}) \end{aligned}$$

Also let
$$\begin{aligned} \hat{W} = [& \widehat{Dy}^*_2, \widehat{Dy}^*_3, \ldots, \widehat{Dy}^*_p, \hat{y}^*_2, \ldots, \\ & \hat{y}^*_p, \hat{\phi} Z,\ Z,\ \hat{\phi}] \end{aligned}$$

Then, the instrumental variable estimator of θ is

$$\hat{\theta} = (\hat{W}, W)^{-1}\ \hat{W}' y^*_1 \tag{22}$$

It can be shown that in this case given the way the instrumental variables are constructed as defined by equations (17) and (15), the instrumental variable estimator is the same as the two-stage squares estimator so that

$$\hat{\theta} = (\hat{W}' \hat{W})^{-1}\ \hat{W}' y^*_1 \tag{22a}$$

The instrumental variable estimator can be easily shown to be consistent. The asymptotic covariance matrix of this estimator is derived in the appendix. It is the last expression in the appendix. Since it involves the definitions of several expressions, it is not repeated here.

4. An Empirical Illustration

The example we consider is the estimation of the effects of college education on earnings based on the project TALENT data. More detailed discussion of the data and their use in this problem can be found in Kenny (1977) and Kenny et. al. (1979). We will here summarize all the salient features of the data and the model relevant for our discussion of the D-method.

Let S = years of college education
E = earnings
X, Z_1, Z_2 are sets of (possibly overlapping) exogenous variables defined in Table 1.

The switching simultaneous equation system we consider is the following:

$$I = X\delta - \varepsilon^* \tag{23}$$

$$S = Z_1 \beta_1 = \varepsilon_{11} \tag{24}$$

iff $I > 0$

$$E = \gamma S + Z_2 \beta_2 + \varepsilon_{12} \tag{25}$$

$$S = 0$$

otherwise

$$E = Z_2 \beta_3 + \varepsilon_{22} \tag{26}$$

I is an indicator function such that if $I > 0$, the individual goes to college and if $I \leq 0$ the individual does not go to college.

The variables in the choice function and the schooling equation, i.e., variables in the sets X and Z_1 are: Rural, Split, MATH, MOCWAG, EDMAL, EDFEM, CHIL. (defined in Table 1).

The variables affecting the earnings functions, i.e., the variables in the set Z_2 are: Rural, MATH, Marital Status and HC (defined in Table 1).

The variable S has been coded as follows:

0 for those with no college education
4.0 for Bachelor's degree
5.5 for Master's degree
6.0 for six years college
8.0 for Ph.D.

with numbers between 0 and 4 for those without bachelor's degree depending on when they dropped out of the 4 year program.

We will briefly discuss the reasoning behind the choice of the variables in the sets X, Z_1, Z_2.

First, regarding the variables X and Z_1 affecting the choice of whether or not to go to college and the years spent in college, high school students coming from rural areas are less likely to go to college or spend more years in college. Hence we included the 'Rural' as a dummy variable. If children are viewed as a

good whose returns are specific to marriage, then divorce would lower the demand for child's educational attainment. Hence we included the variable 'Split' as an explanatory variable and its coefficient is expected to be negative. The variable MATH measures both inherited and achieved cognitive skills. hose with higher MATH scores may learn more rapidly than others and hence may find it optimal to get a higher degree. The variables MOCWAG, EDMAL and EDFEM need no justification. We included the variable CHIL because an increase in the number of children in the parents' household increases the total cost of schooling for the family leading to a reduction in the number of years spent in school.

As for the variables Z_2 affecting the earnings functions, the variable Rural is a crude proxy for cost of living. Individuals who grew up in rural areas, where cost of living (and thus wages) is low, are more likely to live in rural areas than others. The variable MATH measures cognitive achievement and hence should be positively correlated with wages. The variable Marital Status is expected to be positively correlated with wages if we argue that married people have greater responsibilities and hence are likely to work harder. Another argument is that the marriage market may recognize that some men are better 'prospects' (have higher expected wages) than others. Finally the variable HC is used as a proxy for on the job experience. As the number of jobs held (i.e., HC) increases, the amount spent with the current firm is likely to decrease. Hence HC is expected to be negatively correlated with earnings.

Table 2 presents estimates of the parameters δ in equation (23). All the coefficients have the expected signs. Table 3 presents the maximum likelihood estimates of the parameters in equations (24), (25) and (26). Table 4 presents estimates of the parameters of the earnings functions obtained by the D-method described in this paper. The standard errors have been computed from the formula in the appendix.

Our objective in using the D-method is to test which coefficients in the earnings functions are significantly different between the two groups - those with college education and those without. The equations in Table 4 suggest that it is only variables HC and MATH that are significantly different; 'Marital Status' and 'Rural' are not.

The example we have used here as an illustration for the D-method is one where maximum likelihood estimation is feasible. There would, however, be many practical instances where the use of maximum likelihood procedures would be ruled out because of the large size of the model (one example is the model considered by Nelson and Olson [1978]). In such cases the D-method suggested in this paper would be useful to apply tests of significance for equality of coefficients between the two regimes.

5. Conclusions

The paper presents an extension of the Goldfeld-Quant D-method to switching simultaneous equation systems with endogenous switching. The method is useful to apply tests for equality of coefficients across regimes in switching simultaneous equation systems with selectivity The paper derives the valid instrumental variables to use in this situation, the asymptotic covariance matrix of the suggested estimator and gives an empirical illustration.

REFERENCES

Amemiya, T. (1978) - "The Estimation of a Simultaneous Equation Generalized Probit Model," Econometrica, Vol. 46, No. 5, pp. 1193-1205.

Goldfeld, S.M. and R. E. Quandt (1972) - Nonlinear Methods in Econometrics (Amsterdam, North Holland Publishing Co.).

Goldfeld, S. M. and R. E. Quandt (1973) - "The Estimation of Structural Shifts by Switching Regressions," Annals of Economic and Social Measurement, Vol. 2, No. 4, pp. 475-486.

Heckman, J. J. (1976a) - "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimation for Such Models." Annals of Economic and Social Measurement, Vol. 5, No. 4, 475-492.

Heckman, J. J. (1976b) - "Simultaneous Equations Models with Continuous and Discrete Endogenous Variables and Structural Shifts," in Goldfeld and Quandt (Eds), Studies in Non-linear Estimation (Ballinger Publishing Co.).

Kenny, L. W. (1977) - "The Demand for Child Quality and for Educational Inputs, the Production of Child Quality and Related Topics," unpublished doctoral dissertation, University of Chicago.

Kenny, L. W., Lung-fei Lee, G. S. Maddala and R. P. Trost (1979) - "Returns to College Education: An Investigation of Self-Selection Bias Based on the Project Talent Data," International Economic Review, Vol. 20, No. 3.

REFERENCES
(continued)

Maddala, G. S. and F. D. Nelson (1975) - "Switching Regression Models with Exogenous and Endogenous Switching" - American Statistical Association Proceedings of the Business and Economic Statistics Section, December 1975, pp. 423-426.

Nelson, F. D. and L. Olson (1978) - "Specification and Estimation of a Simultaneous Equations Model with Limited Dependent Variables," International Economic Review, Vol. 19, No. 3, 695-709.

APPENDIX

In this appendix we will derive the covariance matrix of the two-stage least squares estimator (22a).

We have

$$(\hat{\Theta}-\Theta) = (\hat{W}'\hat{W})^{-1}\hat{W}'\eta_1$$

where η_{1i}, the ith component of η_1 is given by equation (19). Let us first define the N X N diagonal matrices

$$B = \text{Diag}\,[\phi_1,\phi_2,\ldots\phi_N] \quad (1')$$

$$C = \text{Diag}\,[\Phi_1,\Phi_2,\ldots\Phi_N] \quad (2')$$

$$F = \text{Diag}\,[x_1'\delta, x_2'\delta,\ldots x_N'\delta] \quad (3')$$

$$H = \text{Diag}\,[z_1(\gamma_{11}-\gamma_{21}),\ldots z_N(\gamma_{11}-\gamma_{21})] \quad (4')$$

$$V = \text{Diag}\,[\Phi_1(1-\Phi_k),\ldots\Phi_N(1-\Phi_N)] \quad (5')$$

$$\wedge = \text{Diag}\,\left[\frac{\phi_1^2}{\Phi_1(1-\Phi_1)},\ldots\frac{\phi_N^2}{\Phi_N(1-\Phi_N)}\right] \quad (6')$$

and

$$\wedge_1 = \text{Diag}\,\left[\frac{\phi_1}{\Phi_1(1-\Phi_1)},\ldots\frac{\phi_N}{\Phi_N(1-\Phi_N)}\right] \quad (7')$$

Actually $\wedge = C^2V^{-1}$ and $\wedge_1 = CV^{-1}$ but we have defined these two diagonal matrices separately for convenience.

Also let X be the N X L matrix of observations on x_i, i.e.

$$X = \begin{bmatrix} x_1' \\ x_2' \\ \vdots \\ x_N' \end{bmatrix} \quad (8')$$

Finally define

$$G = H-[H+(\sigma_{\varepsilon 11*}-\sigma_{\varepsilon 21*})F]\,CX(X'\wedge X)^{-1}X'\wedge_1 \quad (9')$$

Now from equation (19), we have

$$\begin{aligned}\hat{\Theta}-\Theta &= (\hat{W}'\hat{W})^{-1}\hat{W}'\eta_1 \\ &= (\hat{W}'\hat{W})^{-1}\hat{W}'\,[\S_1+H(D-\Phi)-H(\hat{\Phi}-\Phi) \\ &\quad + (\sigma_{\varepsilon 11*}-\sigma_{\varepsilon 21*})(\hat{\phi}-\phi)]\end{aligned} \quad (10')$$

where $\S_1$, D, $\hat{\Phi}$, ϕ, $\hat{\phi}$, are all column vectors with their i-th elements $\S_{1i}$, D_i, Φ_i, $\hat{\Phi}_i$, ϕ_i, $\hat{\phi}_i$ respectively.

Expanding $\hat{\Phi}_i$ and ϕ_i up to the first power of $(\hat{\delta}-\delta)$ we get

$$\hat{\Phi}_i \simeq \Phi_i + \left[\frac{\partial\Phi_i}{\partial\delta}\right]'(\hat{\delta}-\delta) = \Phi_i + \phi_i x_i'(\hat{\delta}-\delta)$$

Hence $(\hat{\Phi}-\Phi) \simeq CX(\hat{\delta}-\delta) \quad (11')$

Similarly

$$\hat{\phi}-\phi \simeq -FCX(\hat{\delta}-\hat{\delta}) \quad (12')$$

Hence we have [2] from equation (10')

$$\begin{aligned}\hat{\Theta}-\Theta \overset{A}{=} (\hat{W}'\hat{W})^{-1}\,[\S_1 &+ H(D-\Phi) \\ &- HCX(\hat{\delta}-\delta)-(\sigma_{\varepsilon 11*}-\sigma_{\varepsilon 21*})FCX(\hat{\delta}-\delta)]\end{aligned} \quad (13')$$

Now what we will do is express $(\hat{\delta}-\delta)$ in terms of $(D-\Phi)$ so that all we have to get is Var $(\S_1)$, Var $(D-\Phi)$ and Cov$(\S_1, D-\Phi)$.

Following Amemiya (1977) we can write

$$(\hat{\delta}-\delta) \overset{A}{=} (X'\wedge X)^{-1}X'\wedge_1(D-\Phi) \quad (14')$$

Substituting this in (13') we have

$$(\hat{\Theta}-\Theta) \overset{A}{=} (\hat{W}'\hat{W})^{-1}\hat{W}'\,[\S_1+G(D-\Phi)] \quad (15')$$

where G is defined in (9').

From equation (20) in the text, we have

$$\S_{1i} = \varepsilon_{21i}+D_i\,(\varepsilon_{11i}-\varepsilon_{21i}) - (\sigma_{\varepsilon 21*}-\sigma_{\varepsilon 11*})\phi_i\,.$$

Hence Var $(\S_{1i}) = E(\S_{1i}^2)$

$$\begin{aligned}&= \sigma^2_{21}+(\sigma^2_{11}-\sigma^2_{21})\Phi_i \\ &\quad + (\sigma^2_{\varepsilon 21*}-\sigma^2_{\varepsilon 11*})(x_i'\delta)\phi_i \\ &\quad - (\sigma_{\varepsilon 21*}-\sigma_{\varepsilon 11*})^2\,\phi_i^2\end{aligned}$$

$$\begin{aligned}\text{Or Var}\,(\S_1) &= \sigma^2_{\varepsilon 21}I_N + (\sigma^2_{\varepsilon 11}-\sigma^2_{\varepsilon 21})B \\ &\quad + (\sigma^2_{\varepsilon 21*}-\sigma^2_{\varepsilon 11*})FC \\ &\quad - (\sigma_{\varepsilon 21*}-\sigma_{\varepsilon 11*})^2C^2\end{aligned} \quad (16')$$

Var $(D-\phi) = V$ where V is defined in (5') and hence Var $[G(D-\Phi)] = GVG'$ (17')

Finally, $E[\xi_1(D-\Phi)'] = -\sigma_{\varepsilon 11*} C$

$$+ (\sigma_{\varepsilon 11*} - \sigma_{\varepsilon 21*}) BC \qquad (18')$$

Hence, collecting the expressions (16'), (17'), and (18') we have

$$\begin{aligned} \mathrm{Var}\ (\hat{\Theta}-\Theta) = {} & (\hat{W}'\hat{W})^{-1}\hat{W}'[\sigma^2_{\varepsilon 21} I_N \\ & + (\sigma^2_{\varepsilon 21} I_N + (\sigma^2_{\varepsilon 11}-\sigma^2_{\varepsilon 21}) B \\ & + (\sigma^2_{\varepsilon 21*}-\sigma^2_{\varepsilon 11*}) FC \\ & - (\sigma_{\varepsilon 21*}-\sigma_{\varepsilon 11*})^2 C^2 + GVG' \\ & - \sigma_{\varepsilon 11*} (CG'+GC) \\ & + (\sigma_{\varepsilon 11*}-\sigma_{\varepsilon 21*})(BCG'+GCB)] \\ & \hat{W}\ (\hat{W}'\hat{W})^{-1} \end{aligned}$$

where the expressions B, C, F, G etc. are all defined in equation (1') to (8').

FOOTNOTES:

[1] Richard Quandt kindly pointed out to us that there is an algebraic error in equation (3.8), p. 425 of the Maddala-Nelson paper. The two denominators in Φ should be $(\gamma_2^2\sigma_2^2 + \sigma_3^2)^{1/2}$ and $(\gamma_1^2\sigma_1^2+\sigma_3^2)^{1/2}$ instead of $(\sigma_2^2+\sigma_3^2)^{1/2}$ and $(\sigma_1^2+\sigma_3^2)^{1/2}$ respectively.

[2] In the discussion that follows, the notation A means that the two expressions have the asymptotic distributions.

TABLE 1
LIST OF VARIABLES

E	=	Natural logarithm of the hourly wage (in cents) in 1971
S	=	Years of college education in 1971
MATH	=	Score on a composite of mathematics achievement tests in 1960
SPLIT	=	0 if children living with <u>both</u> mother and father in 1960
	=	1 Otherwise
EDMAL	=	Years of father's education
EDFEM	=	Years of mother's education
CHIL	=	Number of living children (in 1960) in the family in which the respondent grew up
RURAL	=	1 if pupils in grades 9-12 came from an area primarily small town (under 5,000 people) or rural farm
	=	0 Otherwise.

TABLE 1 (cont.)

MOCWAG	=	(mean occupational wage) Log of mean earnings (as of 1960) of full-time workers in father's occupation
HC	=	Number of jobs held between 1965 and 1970
N	=	The total sample size = 1373
N_1	=	Number of observations in the first group (those who went to college = 909)
N_2	=	Number of observations in the second group (those that did not go to college = 464)

TABLE 2
PROBIT EQUATION TO EXPLAIN THE DECISION OF WHETHER OR NOT TO GO TO COLLEGE

Variable	Coeff. Est.	S.E.
Constant	-5.259	2.108
Rural (Dummy)	- .164	.093
Split	- .078	.145
MATH	.015	.001
MOCWAG	.922	.589
EDMAL	.044	.017
EDFEM	.029	.019
CHIL	- .057	.021

TABLE 4
EARNINGS FUNCTIONS WITH D-METHOD

Variables	Equation 1	Equation 2	Equation 3
Constant	5.72467 (0.12918)	5.69896 (0.08953)	5.70961 (0.09773)
Marital Status	0.14620 (0.06281)	0.15656 (0.01298)	0.15511 (0.01808)
Rural	-0.07161 (0.07239)	-0.05352 (0.02185)	-0.05030 (0.02416)
MATH	-0.00359 (0.00231)	-0.00377 (0.00206)	-0.00336 (0.00193)
HC	0.03196 (0.01304)	0.03184 (0.01275)	0.03234 (0.01315)
Φ	0.74827 (0.48986)	0.82369 (0.35637)	0.66080 (0.20604)
Φ	-0.12980 (0.34249)	-0.15768 (0.27731)	
ϕ*Marital	0.01454 (0.08599)		
ϕ*Rural	0.03258 (0.10696)		
ϕ*MATH	0.00560 (0.00306)	0.00589 (0.00262)	0.00507 (0.00226)
ϕ*HC	-0.06444 (0.02026)	-0.06335 (0.01920)	-0.06671 (0.01894)
S	0.05141 (0.04710)	0.05774 (0.03536)	0.04202 (0.02590)

(Table 3 is available from the authors upon request.)

PP 211
Mizrahi, Maurice M., "On Approximating the Circular Coverage Function," 14 pp., Feb 1978, AD A054 429

PP 212
Mangel, Marc, "On Singular Characteristic Initial Value Problems with Unique Solution," 20 pp., Jun 1978, AD A058 535

PP 213
Mangel, Marc, "Fluctuations in Systems with Multiple Steady States. Application to Lanchester Equations," 12 pp., Feb 78 (Presented at the First Annual Workshop on the Information Linkage Between Applied Mathematics and Industry, Naval PG School, Feb 23-25, 1978), AD A071 472

PP 214
Weinland, Robert G., "A Somewhat Different View of The Optimal Naval Posture," 37 pp., Jun 1978 (Presented at the 1976 Convention of the American Political Science Association (APSA/IUS Panel on "Changing Strategic Requirements and Military Posture"), Chicago, Ill., September 2, 1976), AD A056 228

PP 215
Colle, Russell C., "Comments on: Principles of Information Retrieval by Manfred Kochen," 10 pp., Mar 78 (Published as a Letter to the Editor, Journal of Documentation, Vol. 31, No. 4, pages 298-301), December 1975), AD A054 426

PP 216
Colle, Russell C., "Lotka's Frequency Distribution of Scientific Productivity," 18 pp., Feb 1978 (Published in the Journal of the American Society for Information Science, Vol. 28, No. 6, pp. 366-370, November 1977), AD A054 425

PP 217
Colle, Russell C., "Bibliometric Studies of Scientific Productivity," 17 pp., Mar 78 (Presented at the Annual meeting of the American Society for Information Science held in San Francisco, California, October 1976), AD A054 442

PP 218 - Classified

PP 219
Huntzinger, R. LaVar, "Market Analysis with Rational Expectations: Theory and Estimation," 60 pp., Apr 78, AD A054 422

PP 220
Maurer, Donald E., "Diagonalization by Group Matrices," 26 pp., Apr 78, AD A054 443

PP 221
Weinland, Robert G., "Superpower Naval Diplomacy in the October 1973 Arab-Israeli War," 76 pp., Jun 1978 (Published in Seapower in the Mediterranean: Political Utility and Military Constraints, The Washington Papers No. 61, Beverly Hills and London: Sage Publications, 1979) AD A055 564

PP 222
Mizrahi, Maurice M., "Correspondence Rules and Path Integrals," 30 pp., Jun 1978 (Invited paper presented at the CNRS meeting on "Mathematical Problems in Feynman's Path Integrals," Marseille, France, May 22-26, 1978) (Published in Springer Verlag Lecture Notes in Physics, 106, (1979), 234-253) AD A055 536

PP 223
Mangel, Marc, "Stochastic Mechanics of Moleculeion Molecule Reactions," 21 pp., Jun 1978, AD A056 227

PP 224
Manger, Marc, "Aggregation, Bifurcation, and Extinction In Exploited Animal Populations*," 48 pp., Mar 1978, AD A058 536
*Portions of this work were started at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, B.C., Canada

PP 225
Mangel, Marc, "Oscillations, Fluctuations, and the Hopf Bifurcation*," 43 pp., Jun 1978, AD A058 537
*Portions of this work were completed at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, Canada.

PP 226
Ralston, J. M. and J. W. Mann,* "Temperature and Current Dependence of Degradation in Red-Emitting GaP LEDs," 34 pp., Jun 1978 (Published in Journal of Applied Physics, 50, 3630, May 1979) AD A058 538
*Bell Telephone Laboratories, Inc.

PP 227
Mangel, Marc, "Uniform Treatment of Fluctuations at Critical Points," 50 pp., May 1978, AD A058 539

PP 228
Mangel, Marc, "Relaxation at Critical Points: Deterministic and Stochastic Theory," 54 pp., Jun 1978, AD A058 540

PP 229
Mangel, Marc, "Diffusion Theory of Reaction Rates, I: Formulation and Einstein-Smoluchowski Approximation," 50 pp., Jan 1978, AD A058 541

PP 230
Mangel, Marc, "Diffusion Theory of Reaction Rates, II Ornstein-Uhlenbeck Approximation," 34 pp., Feb 1978, AD A058 542

PP 231
Wilson, Desmond P., Jr., "Naval Projection Forces: The Case for a Responsive MAF," Aug 1978, AD A054 543

PP 232
Jacobson, Louis, "Can Policy Changes Be Made Acceptable to Labor?" Aug 1978 (Submitted for publication in Industrial and Labor Relations Review), AD A061 528

*CNA Professional Papers with an AD number may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151. Other papers are available from the Management Information Office, Center for Naval Analyses, 2000 North Beauregard Street, Alexandria, Virginia 22311. An index of Selected Publications is also available on request. The index includes a Listing of Professional Papers; with abstracts; issued from 1969 to June 1981.

PP 233
Jacobson, Louis, "An Alternative Explanation of the Cyclical Pattern of Quits," 23 pp., Sep 1978

PP 234 - Revised
Jondrow, James and Levy, Robert A., "Does Federal Expenditure Displace State and Local Expenditure: The Case of Construction Grants," 25 pp., Oct 1979, AD A061 529

PP 235
Mizrahi, Maurice M., "The Semiclassical Expansion of the Anharmonic-Oscillator Propagator," 41 pp., Oct 1978 (Published in Journal of Mathematical Physics 20 (1979) pp. 844-855), AD A061 538

PP 237
Maurer, Donald, "A Matrix Criterion for Normal Integral Bases," 10 pp., Jan 1979 (Published in the Illinois Journal of Mathematics, Vol. 22 (1978), pp. 672-681

PP 238
Utgoff, Kathleen Classen, "Unemployment Insurance and The Employment Rate," 20 pp., Oct 1978 (Presented at the Conference on Economic Indicators and Performance: The Current Dilemma Facing Government and Business Leaders, presented by Indiana University Graduate School of Business). AD A061 527

PP 239
Trost, R. P. and Warner, J. T., "The Effects of Military Occupational Training on Civilian Earnings: An Income Selectivity Approach," 38 pp., Nov 1979k, AD A077 831

PP 240
Powers, Bruce, "Goals of the Center for Naval Analyses," 13 pp., Dec 1978, AD A063 759

PP 241
Mangel, Marc, "Fluctuations at Chemical Instabilities," 24 pp., Dec 1978 (Published in Journal of Chemical Physics, Vol. 69, No. 8, Oct 15, 1978). AD A063 787

PP 242
Simpson, William R., "The Analysis of Dynamically Interactive Systems (Air Combat by the Numbers)," 160 pp., Dec 1978, AD A063 760

PP 243
Simpson, William R., "A Probabilistic Formulation of Murphy Dynamics as Applied to the Analysis of Operational Research Problems," 18 pp., Dec 1978, AD A063 761

PP 244
Sherman, Allan and Horowitz, Stanley A., "Maintenance Costs of Complex Equipment," 20 pp., Dec 1978 (Published By The American Society of Naval Engineers, Naval Engineers Journal, Vol. 91, No. 6, Dec 1979) AD A071 473

PP 245
Simpson, William R., "The Accelerometer Methods of Obtaining Aircraft Performance from Flight Test Data (Dynamic Performance Testing)," 403 pp., Jun 1979, AD A075 226

PP 246
Brechling, Frank, "Layoffs and Unemployment Insurance," 35 pp., Feb 1979 (Presented at the Nber Conference on "Low Income Labor Markets," Chicago, Jun 1978), AD A096 629

PP 248
Thomas, James A., Jr., "The Transport Properties of Dilute Gases in Applied Fields," 183 pp., Mar 1979, AD A096 464

PP 249
Glasser, Kenneth S., "A Secretary Problem with a Random Number of Choices," 23 pp., Mar 1979

PP 250
Mangel, Marc, "Modeling Fluctuations in Macroscopic Systems," 26 pp., Jun 1979

PP 251
Trost, Robert P., "The Estimation and Interpretation of Several Selectivity Models," 37 pp., Jun 1979, AD A075 941

PP 252
Nunn, Walter R., "Position Finding with Prior Knowledge of Covariance Parameters," 5 pp., Jun 1979 (Published in IEEE Transactions on Aerospace & Electronic Systems, Vol. AES-15, No. 3, Mar 1979

PP 253
Glasser, Kenneth S., "The d-Choice Secretary Problem," 32 pp., Jun 1979, AD A075 225

PP 254
Mangel, Marc and Quanbeck, David B., "Integration of a Bivariate Normal Over an Offset Circle," 14 pp., Jun 1979, AD A096 471

PP 255 - Classified, AD B051 441L

PP 256
Maurer, Donald E., "Using Personnel Distribution Models," 27 pp., Feb 1980, AD A082 218

PP 257
Thaler, R., "Discounting and Fiscal Constraints: Why Discounting is Always Right," 10 pp., Aug 1979, AD A075 224

PP 258
Mangel, Marc S. and Thomas, James A., Jr., "Analytical Methods in Search Theory," 86 pp., Nov 1979, AD A077 832

PP 259
Glass, David V.; Hsu, Ih-Ching; Nunn, Walter R., and Perin, David A., "A Class of Commutative Markov Matrices," 17 pp., Nov 1979, AD A077 833

PP 260
Mangel, Marc S. and Cope, Davis K., "Detection Rate and Sweep Width in Visual Search," 14 pp., Nov 1979, AD A077 834

PP 261
Vila, Carlos L.; Zvijac, David J. and Ross, John, "Franck-Condon Theory of Chemical Dynamics. VI. Angular Distributions of Reaction Products," 14 pp., Nov 1979 (Reprinted from Journal Chemical Phys. 70(12), 15 Jun 1979), AD A076 287

PP 262
Petersen, Charles C., "Third World Military Elites in Soviet Perspective," 50 pp., Nov 1979, AD A077 835

PP 263
Robinson, Kathy I., "Using Commercial Tankers and Containerships for Navy Underway Replenishment," 25 pp., Nov 1979, AD A077 836

PP 264
Weinland, Robert G., "The U.S. Navy in the Pacific: Past, Present, and Glimpses of the Future," 31 pp., Nov 1979 (Delivered at the International Symposium on the Sea, sponsored by the International Institute for Strategic Studies, The Brookings Institution and the Yomiuri Shimbun, Tokyo, 16-20 Oct 1978) AD A066 837

PP 265
Weinland, Robert G., "War and Peace in the North: Some Political Implications of the Changing Military Situation in Northern Europe," 18 pp., Nov 1979 (Prepared for presentation to the Conference of the Nordic Balance in Perspective: The Changing Military and Political Situation," Center for Strategic and International Studies, Georgetown University, Jun 15-16, 1978) AD A077 838

PP 266
Utgoff, Kathy Classen, and Brechling, Frank, "Taxes and Inflation," 25 pp., Nov 1979, AD A081 194

PP 267
Trost, Robert P., and Vogel, Robert C., "The Response of State Government Receipts to Economic Fluctuations and the Allocation of Counter-Cyclical Revenue Sharing Grants," 12 pp., Dec 1979 (Reprinted from the Review of Economics and Statistics, Vol. LXI, No. 3, August 1979)

PP 268
Thomason, James S., "Seaport Dependence and Inter-State Cooperation: The Case of Sub-Saharan Africa," 141 pp., Jan 1980, AD A081 193

PP 269
Weiss, Kenneth G., "The Soviet Involvement in the Ogaden War," 42 pp., Jan 1980 (Presented at the Southern Conference on Slavic Studies in October, 1979), AD A082 219

PP 270
Remnek, Richard, "Soviet Policy in the Horn of Africa: The Decision to Intervene," 52 pp., Jan 1980 (To be published in "The Soviet Union in the Third World: Success or Failure," ed. by Robert H. Donaldson, Westview Press, Boulder, Co., Summer 1980), AD A081 195

PP 271
McConnell, James, "Soviet and American Strategic Doctrines: One More Time," 43 pp., Jan 1980, AD A081 192

PP 272
Weiss, Kenneth G., "The Azores in Diplomacy and Strategy, 1940-1945, 46 pp., Mar 1980, AD A085 094

PP 273
Nakada, Michael K., "Labor Supply of Wives with Husbands Employed Either Full Time or Part Time," 39 pp., Mar 1980, AD A082 220

PP 274
Nunn, Walter R., "A Result in the Theory of Spiral Search," 9 pp., Mar 1980

PP 275
Goldberg, Lawrence, "Recruiters Advertising and Navy Enlistments," 34 pp., Mar 1980, AD A082 221

PP 276
Goldberg, Lawrence, "Delaying an Overhaul and Ship's Equipment," 40 pp., May 1980, AD A085 095

PP 277
Mangel, Marc, "Small Fluctuations in Systems with Multiple Limit Cycles," 19 pp., Mar 1980 (Published in SIAM J. Appl. Math., Vol. 38, No. 1, Feb 1980) AD A086 229

PP 278
Mizrahi, Maurice, "A Targeting Problem: Exact vs. Expected-Value Approaches," 23 pp., Apr 1980, AD A085 096

PP 279
Walt, Stephen M., "Causal Inferences and the Use of Force: A Critique of Force Without War," 50 pp., May 1980, AD A085 097

PP 280
Goldberg, Lawrence, "Estimation of the Effects of A Ship's Steaming on the Failure Rate of its Equipment: An Application of Econometric Analysis," 25 pp., Apr 1980, AD A085 098

PP 281
Mizrahi, Maurice M., "Comment on 'Discretization Problems of Functional Integrals in Phase Space'," 2 pp., May 1980, published in "Physical Review D", Vol. 22 (1980), AD A094 994

PP 283
Dismukes, Bradford, "Expected Demand for the U.S. Navy to Serve as An Instrument of U.S. Foreign Policy: Thinking About Political and Military Environmental Factors," 30 pp., Apr 1980, AD A085 099

PP 284
J. Kellson,* W. Nunn, and U. Sumita,** "The Laguerre Transform," 119 pp., May 1980, AD A085 100
*The Graduate School of Management, University of Rochester and the Center for Naval Analyses
**The Graduate School of Management, University of Rochester

PP 285
Remnek, Richard B., "Superpower Security Interests in the Indian Ocean Area," 26 pp., Jun 1980, AD A087 113

PP 286
Mizrahi, Maurice M., "On the WKB Approximation to the Propagator for Arbitrary Hamiltonians," 25 pp., Aug 1980 (Published in Journal of Math. Phys., 22(1) Jan 1981), AD A091 307

PP 287
Cope, Davis, "Limit Cycle Solutions of Reaction-Diffusion Equations," 35 pp., Jun 1980, AD A087 114

PP 288
Golman, Walter, "Don't Let Your Slides Flip You: A Painless Guide to Visuals That Really Aid," 28 pp., Oct 1980, AD A092 732

PP 289
Robinson, Jack, "Adequate Classification Guidance - A Solution and a Problem," 7 pp., Aug 1980, AD A091 212

PP 290
Watson, Gregory H., "Evaluation of Computer Software in an Operational Environment," 17 pp., Aug 1980, AD A091 213

PP 291
Maddala, G. S.* and Trost, R. P., "Some Extensions of the Nerlove Press Model," 17 pp., Oct 1980, AD A091 946
*University of Florida

PP 292
Thomas, James A., Jr., "The Transport Properties of Binary Gas Mixtures in Applied Magnetic Fields," 10 pp., Sept 1980 (Published in Journal of Chemical Physics 72(10), 15 May 1980

PP 293
Thomas, James A., Jr., "Evaluation of Kinetic Theory Collision Integrals Using the Generalized Phase Shift Approach," 12 pp., Sept 1980 (Printed in Journal of Chemical Physics 72(10), 15 May 1980

PP 294
Roberts, Stephen S., "French Naval Policy Outside of Europe," 30 pp., Sept 1980 (Presented at the Conference of the Section on Military Studies, International Studies Association Kiawah Island, S.C.), AD A091 306

PP 295
Roberts, Stephen S., "An Indicator of Informal Empire: Patterns of U.S. Navy Cruising on Overseas Stations, 1869-1897," 40 pp., Sept 1980 (Presented at Fourth Naval History Symposium, US Naval Academy, 26 October 1979, AD A091 316

PP 296
Dismukes, Bradford and Petersen, Charles C., "Maritime Factors Affecting Iberian Security," (Factores Maritimos Que Afectan La Securidad Ibeica) 14 pp., Oct 1980, AD A092 733

PP 297 – Classified

PP 298
Mizrahi, Maurice M., "A Markov Approach to Large Missile Attacks," 31 pp., Jan 1981, AD A096,159

PP 299
Jondrow, James M. and Levy, Robert A., "Wage Leadership in Construction, 19 pp., Jan 1981, AD A094 797

PP 300
Jondrow, James and Schmidt, Peter,* "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model," 11 pp., Jan 1981, AD A096 159
*Michigan State University

PP 301
Jondrow, James M.; Levy, Robert A. and Hughes, Claire, "Technical Change and Employment in Steel, Autos, Aluminum, and Iron Ore, 17 pp., Mar 1981, AD A099 394

PP 302
Jondrow, James M. and Levy, Robert A., "The Effect of Imports on Employment Under Rational Expectations," 19 pp., Apr 1981, AD A099 392

PP 303
Thomason, James, "The Rarest Commodity in the Coming Resource Wars," 3 pp., Aug 1981 (Published in the Washington Star, April 13, 1981)

PP 304
Duffy, Michael K.; Greenwood, Michael J.* and McDowell, John M.,** "A Cross-Sectional Model of Annual Interregional Migration and Employment Growth: Intertemporal Evidence of Structural Change, 1958-1975," 31 pp., Apr 1981, AD A099 393
*University of Colorado
**Arizona State University

PP 305
Nunn, Laura H., "An Introduction to the Literature of Search Theory," 32 pp., Jun 1981

PP 306
Anger, Thomas E., "What Good Are Warfare Models?" 7 pp., May 1981

PP 307
Thomason, James, "Dependence, Risk, and Vulnerability," 43 pp., Jun 1981

PP 308
Mizrahi, M.M., "Correspondence Rules and Path Integrals," Jul 1981. Published in "Nuovo Cimento B", Vol. 61 (1981)

PP 309
Weinland, Robert G., "An (The?) Explanation of the Soviet Invasion of Afghanistan," 44 pp., May 1981

PP 310
Stanford, Janette M. and Tai Te Wu,* "A Predictive Method for Determining Possible Three-dimensional Foldings of Immunoglobulin Backbones Around Antibody Combining Sites," 19 pp., Jun 1981 (Published in J. theor. Biol. (1981) 88, 421-439
*Northwestern University, Evanston, IL

PP 311
Bowes, Marianne, Brechling, Frank P. R., and Utgoff, Kathleen P. Classen, "An Evaluation of UI Funds," 13 pp., May 1981 (Published in National Commission on Unemployment Compensation's Unemployment Compensation: Studies and Research, Volume 2, July 1980)

PP 312
Jondrow, James; Bowes, Marianne and Levy, Robert, "The Optimum Speed Limit," 23 pp., May 1981

PP 313
Roberts, Stephen S., "The U.S. Navy in the 1980s," 36 pp., Jul 1981

PP 314
John, Christopher; Horowitz, Stanley A. and Lockman, Robert F., "Examining the Draft Debate," 20 pp., Jul 1981

PP 315
Buck, Ralph V., Capt., "Le Catastrophe by any other name...," 4 pp., Jul 1981

PP 316
Roberts, Stephen S., "Western European and NATO Navies, 1980," 20 pp., Aug 1981

PP 317
Roberts, Stephen S., "Superpower Naval Crisis Management in the Mediterranean," 35 pp., Aug 1981

PP 318
Vego, Milan N., "Yugoslavia and the Soviet Policy of Force in the Mediterranean Since 1961," 187 pp., Aug 1981

PP 319
Smith, Michael W., "Antiair Warfare Defense of Ships at Sea," 46 pp., Sep 1981 (This talk was delivered at the Naval Warfare System and Technology Conference of the American Institute of Aeronautics and Astronautics in Washington on December 12, 1980; in Boston on January 20, 1981; and in Los Angeles on June 12, 1981.)

PP 320
Trost, R.P.; Lurie, Philip and Berger, Edward, "A Note on Estimating Continuous Time Decision Models," 15 pp., Sep 1981

PP 321
Duffy, Michael K. and Ladman, Jerry R.,* "The Simultaneous Determination of Income and Employment in United States--Mexico Border Region Economies," 34 pp., Sep 1981
*Associate Professor of Economics, Arizona State University, Tempe, AZ.

PP 322
Warner, John T., "Issues in Navy Manpower Research and Policy: An Economist's Perspective," 66 pp., Dec 1981

PP 323
Bomse, Frederick M., "Generation of Correlated Log-Normal Sequences for the Simulation of Clutter Echoes," 33 pp., Dec 1981

PP 324
Horowitz, Stanley A., "Quantifying Seapower Readiness," 6 pp., Dec 1981 (Published in Defense Management Journal, Vol. 18, No. 2)

PP 327
Hammon, Colin, Capt., USN and Graham, David R., Dr., "Estimation and Analysis of Navy Shipbuilding Program Disruption Costs," 12 pp., Mar 1980

PP 328
Weinland, Robert G., "Northern Waters: Their Strategic Significance," 27 pp., Dec 1980

PP 330
Lockman, Robert F., "Alternative Approaches to Attrition Management," 30 pp., Jan 1982

PP 333
Lee, Lung-Fei and Trost, Robert P., "Estimation of Some Limited Dependent Variable Models with Application to Housing Demand," 26 pp., Jan 1982. Published in Journal of Econometrics 8 (1978) 357-382.

PP 334
Kenny, Lawrence W., Lee, Lung-Fei, Maddala, G.S., and Trost R.P., "Returns to College Education: An Investigation of Self-Selection Bias Based on the Project Talent Data," 15 pp., Jan 1982. Published in International Economic Review, Vol. 20, No. 3, October 1979.

PP 335
Lee, Lung-Fei, G.S. Maddala, and R.P. Trost, "Asymptotic Covariance Matrices of Two-Stage Probit and Two-Stage Tobit Methods for Simultaneous Equations Models with Selectivity," 13 pp., Jan 1982. Published in Econometrica, Vol. 48, No. 2 (March, 1980).

PP 336
O'Neill, Thomas, "Mobility Fuels for the Navy," 13 pp., Jan 1982. Accepted for publication in Naval Institute Proceedings.

PP 337
Warner, John T. and Goldberg, Matthew S., "The Influence of Non-Pecuniary Factors on Labor Supply," 23 pp., Dec 1981

PP 339
Wilson, Desmond P., "The Persian Gulf and the National Interest," 11 pp., Feb 1982

PP 340
Lurie, Philip, Trost, R.P., and Berger, Edward, "A Method for Analyzing Multiple Spell Duration Data," 34 pp., Feb 1982

PP 341
Trost, Robert P. and Vogel, Robert C., "Prediction with Pooled Cross-Section and Time-Series Data: Two Case Studies," 6 pp., Feb 1982

PP 342
Lee, Lung-Fei, Maddala, G.S., and Trost, R.P., "Testing for Structural Change by D-Methods in Switching Simultaneous Equations Models," 5 pp., Feb 1982

PP 343
Goldberg, Matthew S., "Projecting the Navy Enlisted Force Level," 9 pp., Feb 1982

ILMED

8